charge carriers are smaller than the metal work function of the transition metal surface thereby precluding exoelectron emission, the energy of the hot-charged carriers may be sufficiently large enough to enable the charge carriers to be collected by crossing a smaller potential barrier. As will be described below the direct detection of chemisorption-induced electron-hole pairs is feasible using a Schottky barrier by transition metal-semiconductor diode detector. The invention shall be described in terms of an atomic hydrogen adsorption on copper and silver film surfaces, however, it is to be expressly understood that many other chemical molecules or elements may be detectable on these and other different thin film metal surfaces according to the teachings of the invention. Silver and copper film surfaces exhibit high reactivity to atomic hydrogen, but negligible dissassociative adsorption of molecular hydrogen, H_2. The formation energy of the hydrogen-metal bond is large, about 2.5 electron volts in both cases. To detect the hot charged carriers, a sensor is provided which is comprised of a large area of metal-semiconductor contact with an ultrathin metal film.

[0014] The device structure allows current-voltage curves to be measured from which Schottky barrier heights and ideality factors as a function of metal film thickness can be determined. It is observed that barrier heights increases and ideality factors decreases with increasing metal film thickness (10 Angstroms to 100 Angstroms). Room temperature annealing of diodes produced with a low temperature metalization increases the measured barrier heights and lowers the ideality factors. The magnitude of these effects depends on the metal used. Results for iron and copper on silicon (111) substrates are among the embodiments described below.

[0015] The rectifying properties of the Schottky diode formed are improved by annealing the devices to room temperature and cooling back to 135° K. The measured I-V curves can then be analyzed using thermionic emission theory. Effective barrier heights of 0.6-0.65 electron volts and 0.5-0.55 electron volts were determined for copper and silver films of 75 angstrom thickness on n-silicon (111), respectively. On p-silicon (111), silver and copper diodes showed barriers of 0.5-0.6 electron volts. Ideality factors between 1.05 and 1.5 indicate that large-area diodes are laterally nonuniform and exhibit a barrier height distribution.

[0016] The invention now having been briefly summarized turn to the following drawings wherein like elements are referenced by like numerals.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] **FIG. 1**(*a*) is a Fermi diagram of the chemicurrent detection. Hydrogen atoms react with the metal surface creating electron-hole pairs. The hot electrons travel ballistically through the film into the semiconductor where they are detected.

[0018] **FIG. 1**(*b*) is a schematic side cross-sectional view through a hydrogen sensing Schottky diode made according to the invention as described by the Fermi diagram of **FIG. 1**(*a*). The ultrathin metal film is connected to the gold pad during evaporation.

[0019] **FIG. 1**(*c*) is a plan elevational view of the device of FIGS. **1**(*a*) and **1**(*b*).

[0020] FIGS. **2**(*a*) and **2**(*b*) are graphs of the chemicurrent as a function of hydrogen exposure time for diodes with thin silver and copper films respectively in a device shown in FIGS. **1**(*a*) and **1**(*b*). The transients correspond to the filling of empty adsorption sites by atomic hydrogen on the metal surfaces. The steady-state currents are explained by a balance of abstraction and re-adsorption of atomic hydrogen.

[0021] **FIG. 3** is a graph of the chemicurrent, I, as a function of time, t, recorded from silver/n-Si (111) diodes of the type shown in FIGS. **1**(*a*) and **1**(*b*) exposed to atomic hydrogen and deuterium. The chemicurrent due to atomic hydrogen adsorption is multiplied by a factor of 0.3.

[0022] **FIG. 4** is a graph of the chemisorption current for a 60 Angstrom Ag/Si (111) sensor at 135K as a function of the time of exposure to CO.

[0023] **FIG. 5** is a graph of the chemisorption current for an 80 Angstrom Ag/Si (111) sensor at 135K as a function of the time of exposure to CO.

[0024] **FIG. 6** is a diagrammatic side view of a sensor used for catalytic chemisorption detection.

[0025] **FIG. 7** is an array of sensors of the type shown in **FIG. 10** in which each one of the sensors has a different catalytic layer so the corresponding sensor detects a different reactant.

[0026] **FIG. 8** is a graph of the chemisorption current for molecular oxygen on a 75 Angstrom Ag/Si (111) sensor at 130K as a function of the time of exposure to O_2.

[0027] The invention now having been illustrated in the foregoing drawing the invention and its various embodiments now may be understood in context in the following detailed description.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0028] Electron-hole production at a Schottky barrier has recently been observed experimentally as a result of chemical processes. This conversion of chemical energy to electronic energy may serve as a basic link between chemistry and electronics and offers the potential for the generation of unique electronic signatures for chemical reactions and the creation of a new class of solid state chemical sensors. The initial results have been for a atomic and molecular adsorption, however, it also expected that bimolecular surface catalyzed reactions may also cause direct excitation of charge carriers during the formation of bonds between surface adsorbed species. Therefore, in addition to the demonstrated detection of hydrogen, deuterium and oxygen, sensitivity for chemisoprtion for carbon monoxide, carbon dioxide, molecular and atomic oxygen, molecular and atomic nitrogen, nitrogen monoxide and organic hydrocarbons and other species is expected. Detector responses to surface catalyzed reactions of several different combinations of these species following adsorption are expected to produce a chemicurrent including reactions with the combinations of carbon monoxide and molecular oxygen, carbon monoxide with nitrogen oxide and molecular hydrogen and oxygen. The basic configuration of the detector can be extended to include selective coatings, mult-juncition arrays, and tunnel junctions.